SeCURE
Saltwater intrusion and climate change: monitoring, countermeasures and informed governance

D2.3.4 – Apps for real time monitoring

July 2023 – Final version

Contributing partners:
LP – UNIPD, PP3 – UNIST

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1. Introduction

The smartphone App prototypes developed by the LP and UNIST within the MoST project were updated, also following the recommendations arisen from the previous Standard IT-HR project. Specifically, the smartphone Apps were developed to acquire various parameters as listed below.

<u>Italian site:</u>

- Real-time acquisition of soil temperature, water content, and electrical conductivity at four depths per each of the five monitoring stations established in the Venice farmland;
- Real-time acquisition of air temperature, atmospheric pressure, lightning activity, precipitation, solar radiation, wind direction and speed for the meteo-climatic station;
- Real-time acquisition of the info from the drain intake, i.e. the water conductivity in the Morto Channel and the water discharge that is released in the field through the drain pite;
- Daily time-span acquisition of the groundwater parameters (water level, conductivity and temperature) acquired by the Diver sensors put in place by PP1 in deep boreholes;
- The App possess a warning system for each sensor. The most useful are those associated to the groundwater and water-channel conductivity, suitable for the farmers to manage irrigation;
- The App is characterized by an open friendly version easily usable by the target groups, with graphs showing the behavior vs time of the monitored parameters.

<u>Croatian site:</u>

- SeCure App covers for in total 6 monitoring locations, capturing in total 33 sensors for piezometric head, EC and temperature;
- In total 3 surface water monitoring stations with piezometric head, EC and temperature have been covered by the SeCure app;

- In total 3 unconfined aquifer monitoring stations with piezometric head, EC and temperature have been covered by the SeCure app. The above mentioned parameters have been observed at two different depths due to the previously observed stratigraphy in the salinity;
- In total 2 subsurface confined aquifer monitoring stations with piezometric head, EC and temperature have been covered by the SeCure app.
- App enables the insight to real time data sets with 15 min time step and delay time of app. 10 seconds;
- Following the FAO Guidelines for the standards for water for irrigation, SeCure App indicates the suitability of the water for the irrigation.
- A warning system for each sensor, most useful that on the groundwater and water-channel conductivity, suitable for the farmers to manage irrigation;
- An open friendly version easily usable by the target groups, with graphs showing the behavior vs time of the monitored parameters.

2. The MoST/SeCure – Italian site

2.1 The MoST/SeCure App features

The MoST/SeCure smartphone App is freely downloadable from the website https://most.dicea.unipd.it from the “Query & Download dataset” menu, “MoST App dataset” page. At the page bottom there it the “Download Android App” link.

A few print-screens of the main App features are provided in Fig. 1to Fig. 4.

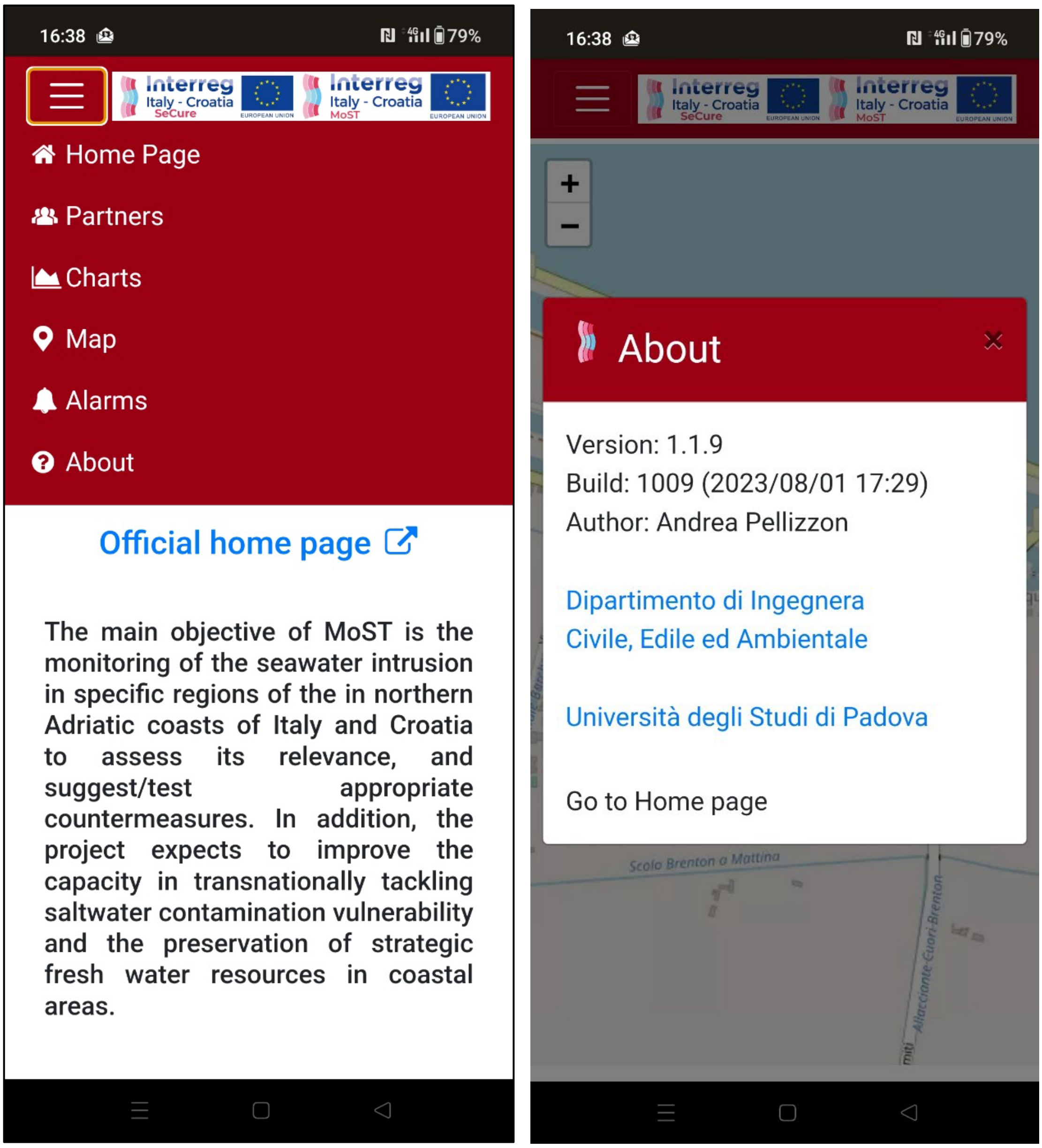

Fig. 1 – Main page and developer page of the MoST/SeCure App .

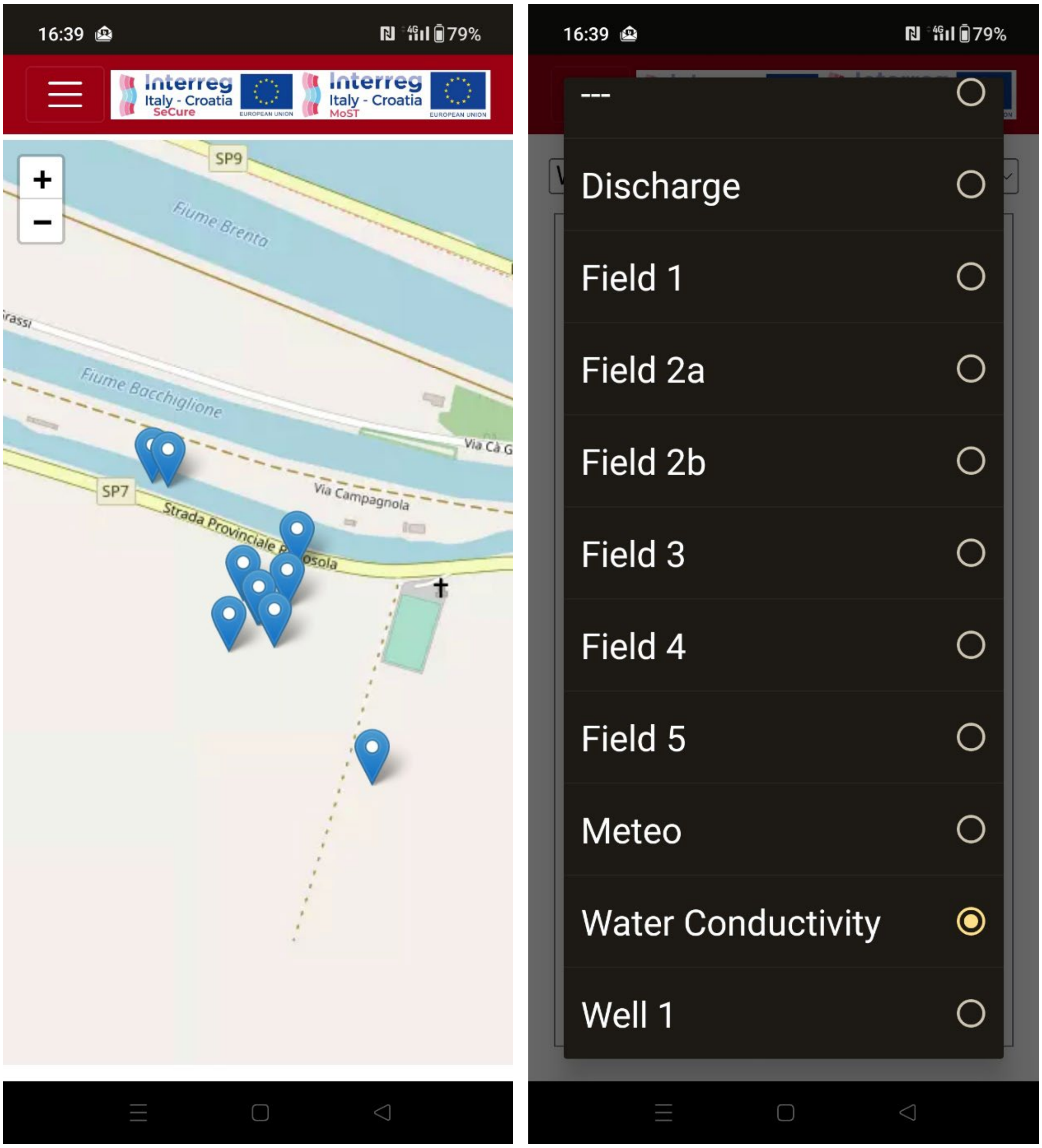

Fig. 2 – Map and list of the monitoring sites.

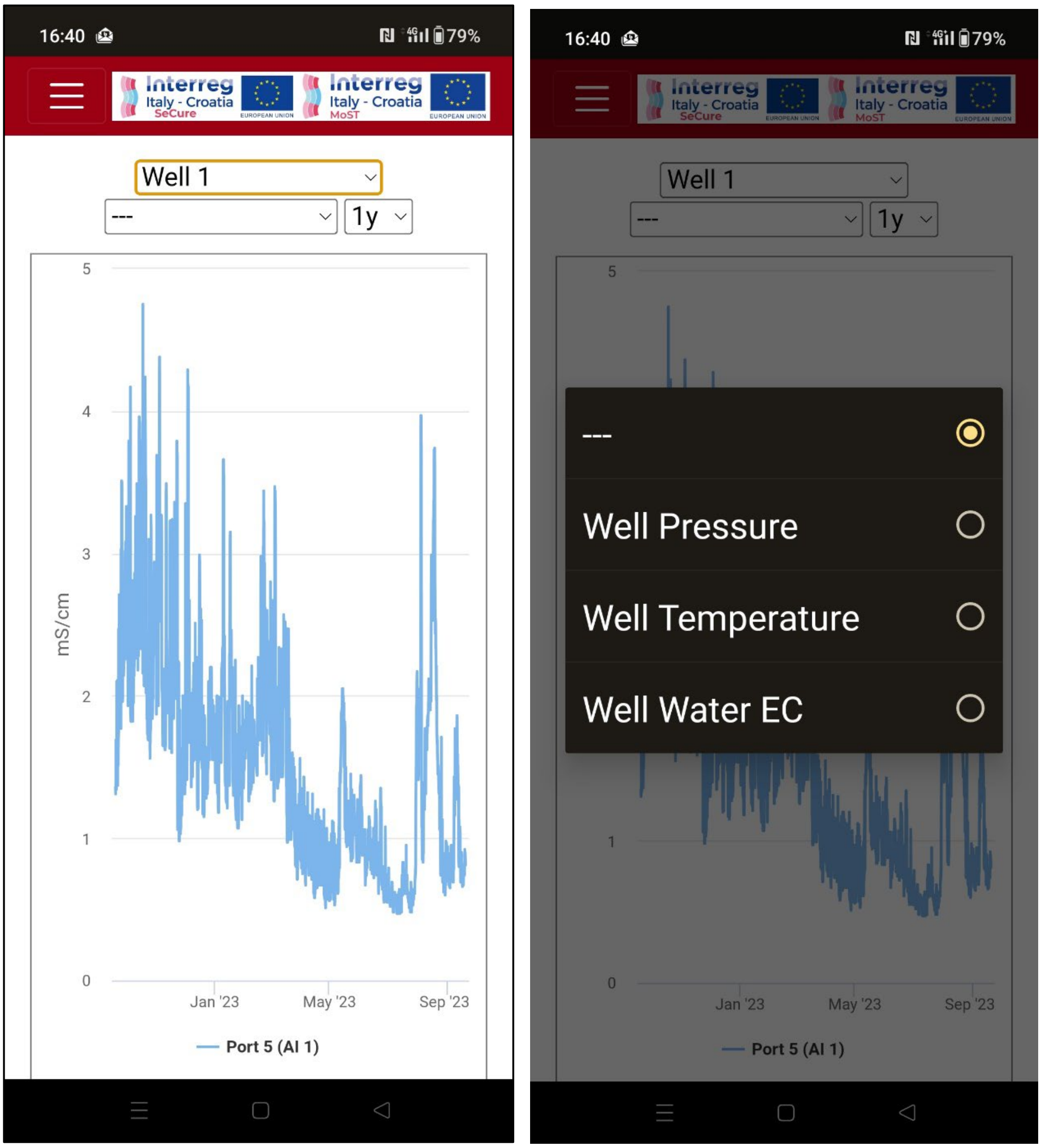

Fig. 3 – Example of the parameters monitored in site Well1 and graph of the water EC during a selected time interval.

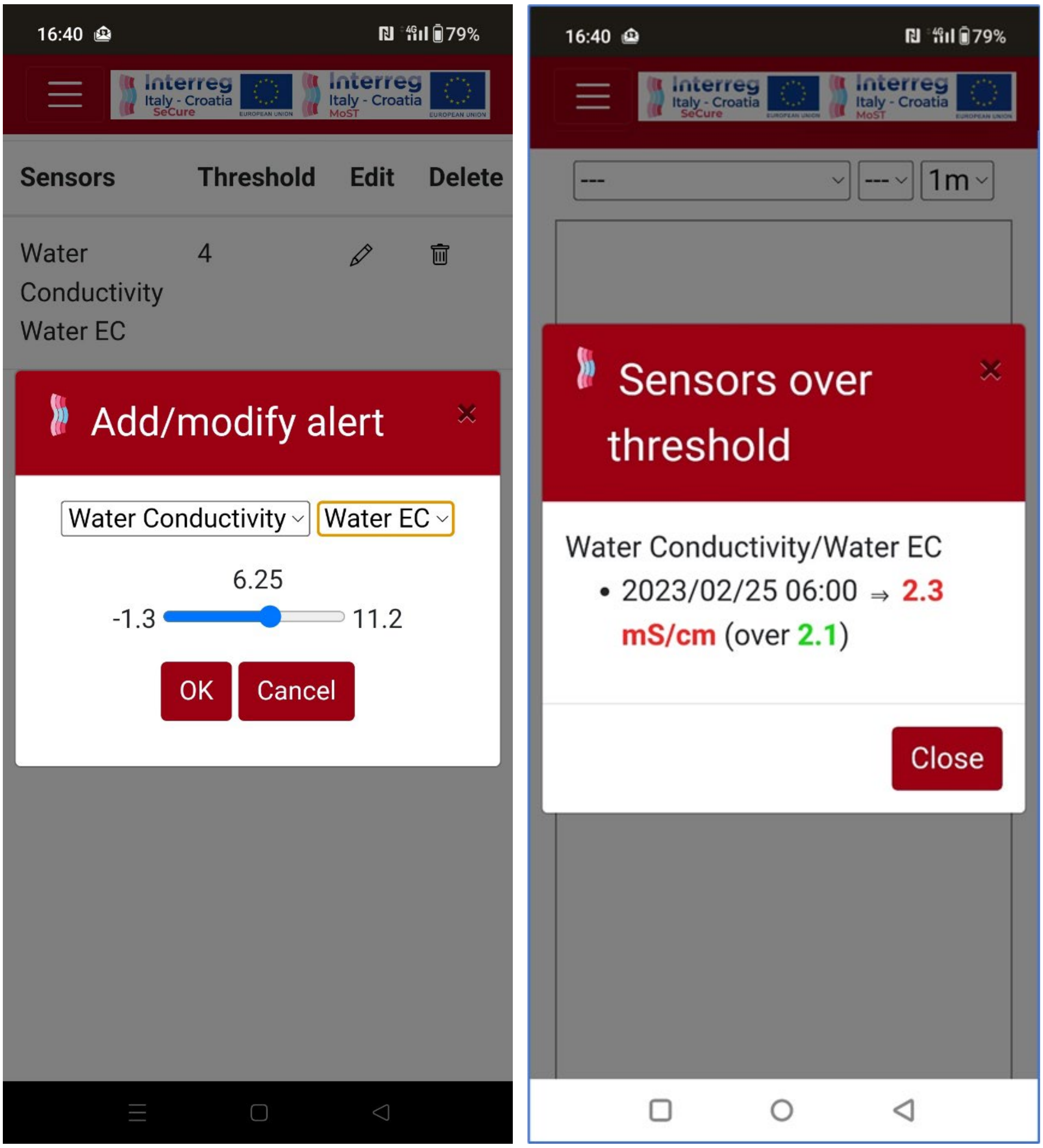

Fig. 4 – Alarm pages: setting (left) and sent message (right). Each user can set the alarm of each sensor as preferred.

2.2 The MoST/SeCure App software

The MoST/SeCure smartphone App was programmed entirely by the LP. The present version acquires, stores, and visualizes the measurements from three groups of sensors, each of them required a specific communication protocol and data management.

2.2.1 Field sensors

The sensors established every crop season within the field are managed through the ZENTRA Cloud system (https://www.metergroup.com/en/meter-environment/zentra-cloud) by Meter Group Inc., USA. A coupled of print-screens of the ZENTRA page for the MoST/SeCure sensors are shown in Fig. 5 and Fig. 6.

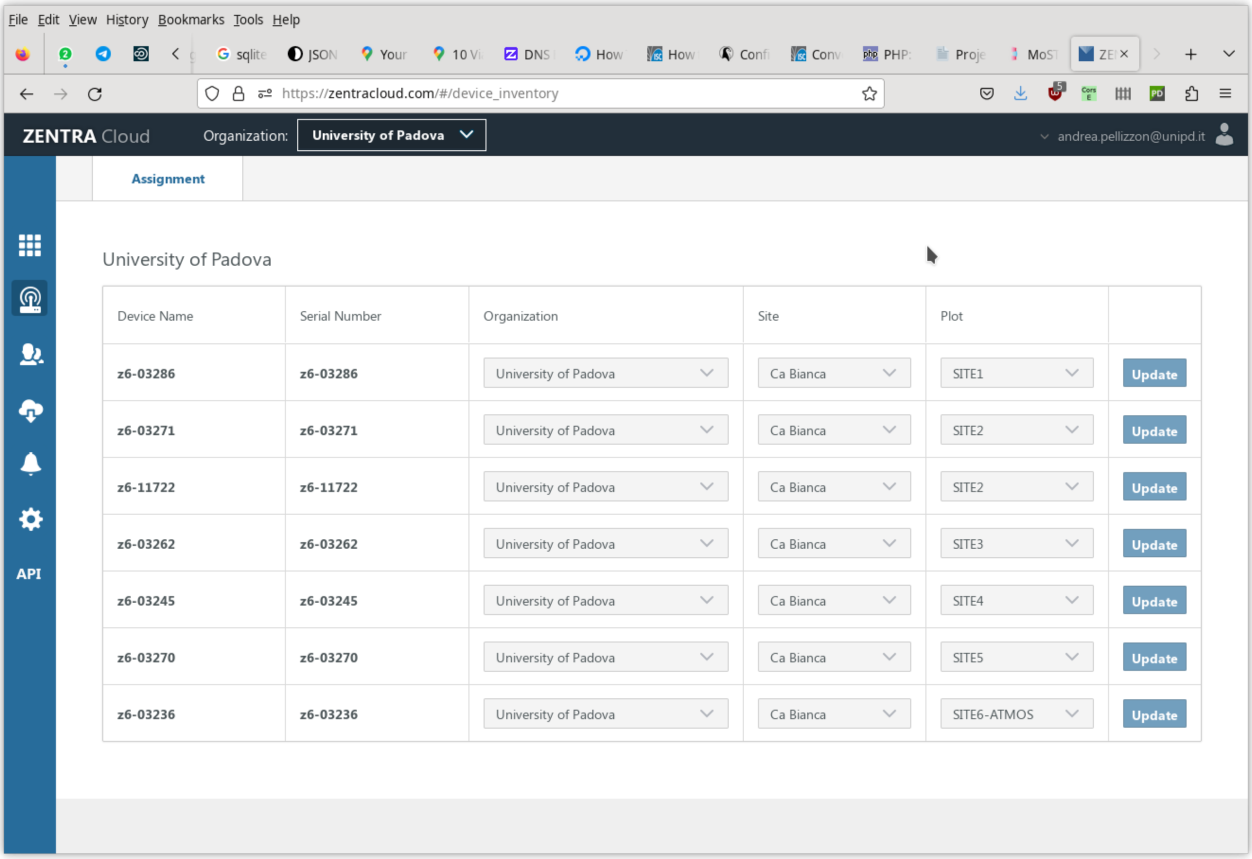

Fig. 5 – ZENTRA webpage with the list of the sensors established in the MoST/Secure field.

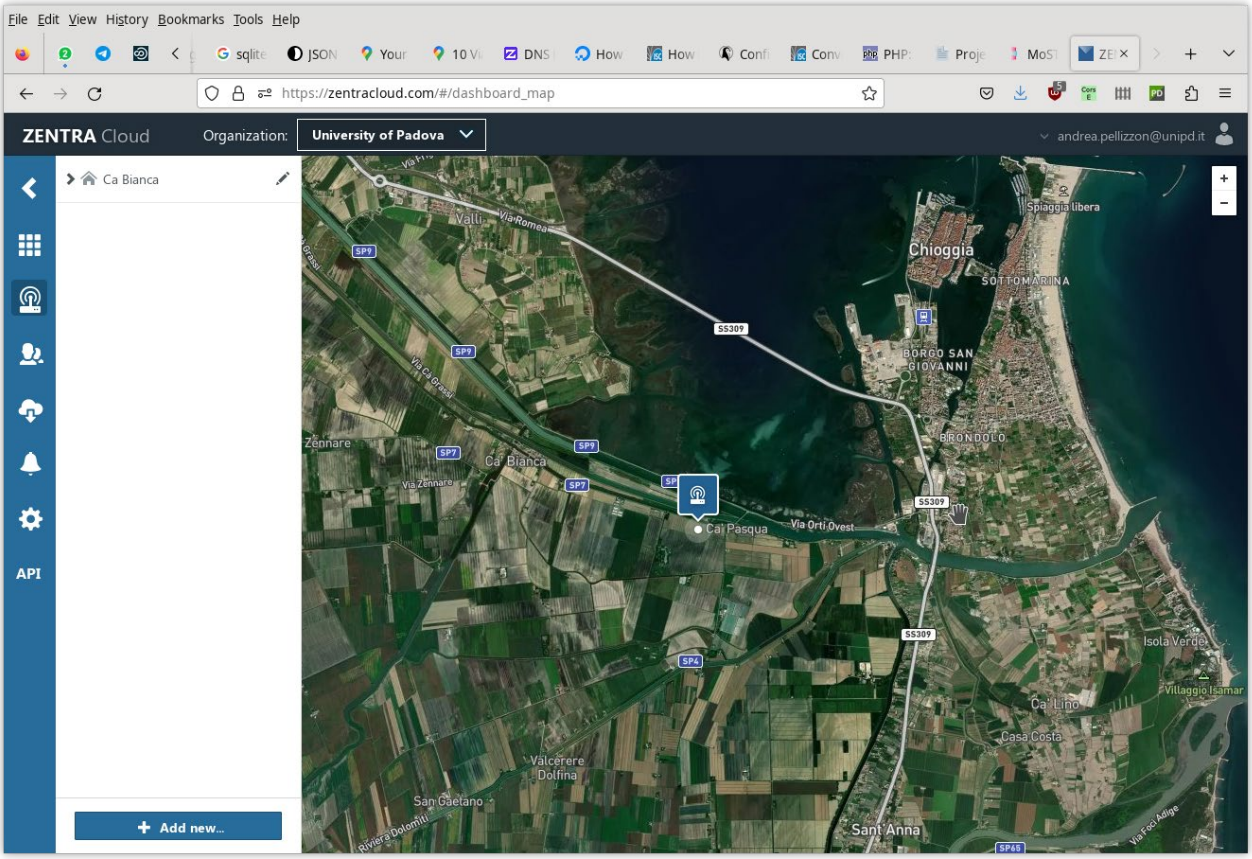

Fig. 6 – ZENTRA webpage with the map of the MoST/Secure field.

The records are sent automatically from the ZENTRA Cloud to the MoST/SeCure App when required by the user. The data format is .json . Two php codes were programmed to import the data into a database host in the LP server (import.php, Fig. 7) and, subsequently, to insert the dataset in the App (insert_data.php, Fig. 8).

```php
<?php

$dir = dirname(__FILE__);
require_once "$dir/insert_data.php";

$output_db = "$dir/full_data_simplified.db";
$output_db = "$dir/full_data2.db";
$output_db = "$dir/full_data4.db";


if ($argc > 1) {
  $files = $argv;
  array_shift($files);
}

$i = new insert_data($output_db);
$i->debug(true);

foreach($files as $fname) {
  error_log("Importing $fname");
  $result = file_get_contents($fname);

  $obj=json_decode($result);
  $j=$obj->data;

  $j = json_encode($j);

  $i->insert($j);
}


?>
```

Fig. 7 – The import.php code.

```php
1   <?php
2
3   class insert_data {
4     private $db = null;
5     private $fname = "";
6     private $rw = null;
7     private $debug = false;
8
9     function __construct($name) {
10      $this->fname = $name;
11      $this->open_rw();
12      $this->open_ro();
13    }
14
15    function __destructor() {
16      $this->db->close();
17      $this->db = null;
18      $this->fname = "";
19    }
20
21    function open_rw() {
22      if ($this->rw === true) return;
23      if ($this->db != null) $this->db->close();
24      $this->db = new SQLite3($this->fname, SQLITE3_OPEN_READWRITE | SQLITE3_OPEN_CREATE);
25      $this->rw = true;
26    }
```

... lines 27 to 210

```php
211         $query = "select max(value) as max_v from read where sensor=$sens";
212         if (is_numeric($a['maxval']))
213           $query .= " and value < " . $a['maxval'];
214         $res = $this->db->query($query);
215         $b = $res->fetchArray(SQLITE3_ASSOC);
216         if (is_numeric($b['max_v'])) {
217           if (is_numeric($a['max']) == false) $a['max'] = $b['max_v'] - 1;
218           //if ($this->debug) error_log("$sens max_v: " . $b['max_v'] . "   max: " . $a['max'] . PHP_EOL);
219           if ($a['max'] < $b['max_v'])
220             $final_query .= "update sensors set max=" . $b['max_v'] . " where id=$sens;";
221         }
222       }
223
224       if ($this->debug) error_log($final_query);
225       if ($final_query != "") {
226         $query = "BEGIN TRANSACTION; " . $final_query . " COMMIT;";
227         $this->open_rw();
228         $this->db->exec($final_query);
229         $this->open_ro();
230         #error_log($query);
231       }
232     }
233
234     function close() {
235       $this->db->close();
236       $this->db = null;
237       $this->fname = "";
238     }
239   }
240   ?>
```

Fig. 8 – The (part of) insert_data.php code.

2.2.2 Drain sensors

The sensors permanently established at the drain inlet are used to measure the water conductivity in the Morto Channel and the discharge from the drain. These data are acquired through the WEB SCADA software (https://www.atsweb.info/web-scada.html) and visualize by the communication platform developed by Lacroix Tech, France. A coupled of print-screens of the Lacroix page for the MoST/SeCure sensors are shown in Fig. 9 and Fig. 10.

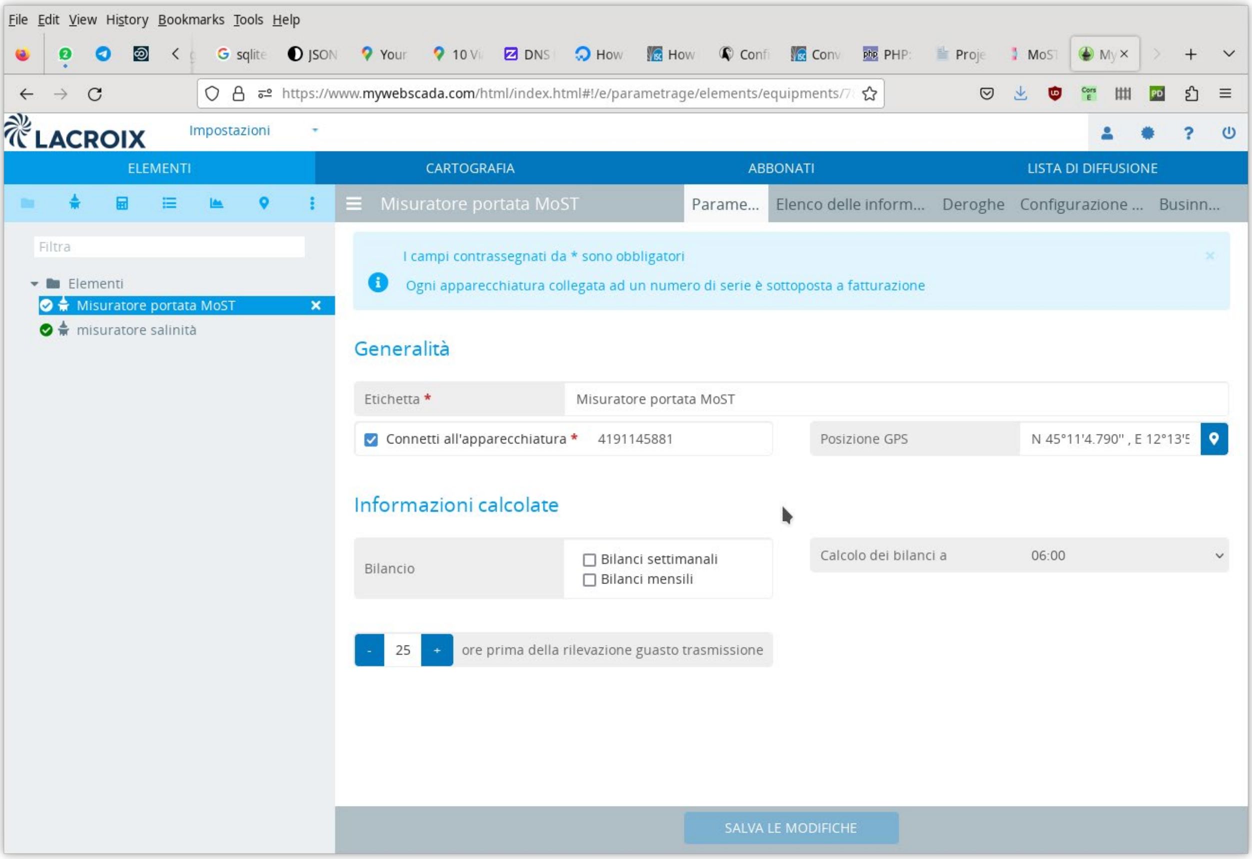

Fig. 9 – Lacroix webpage with the list of the sensors established in the MoST/Secure site.

The records are downloaded from the Lacroix site every 24 hours (a most frequent download can be planned at the expense of a faster battery drain). The convert-scada.php software (Fig. 11) was develop to convert the records in the .json format, after which the import.php (Fig. 7) and insert_data.php (Fig. 8) codes are use as in the previous case.

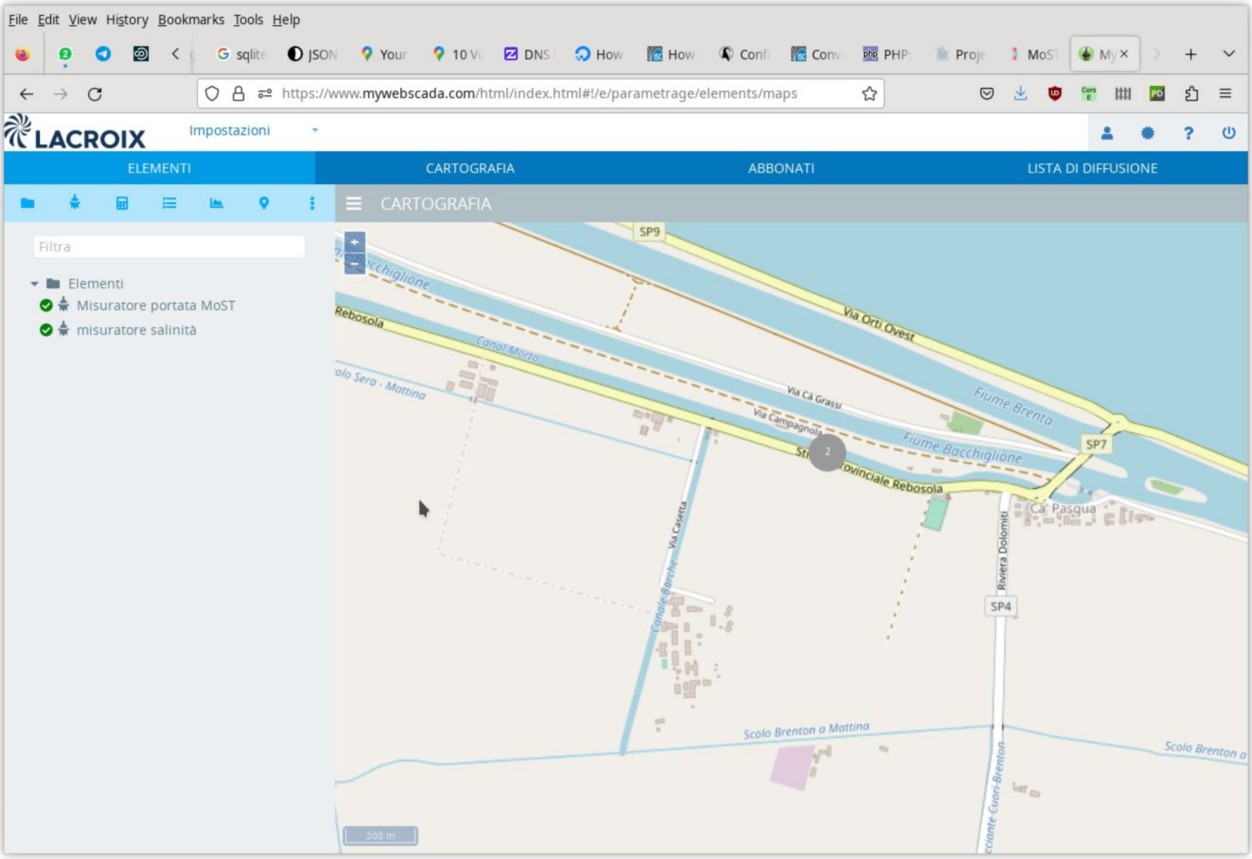

Fig. 10 – Lacroix webpage with the location of the sensors established in the MoST/Secure site.

```
1   <?php
2   #require_once "insert_data.php";
3
4   $output_db = "test.db";
5   $debug = 0;
6
7   $files = [ 'Misuratore_portata_MoST-1665133784.csv', 'Misuratore_salinita_MoST-1665133784.csv'];
8
9   if ($argc > 1) {
10    $files = $argv;
11    array_shift($files);
12  }
13
14  setlocale(LC_CTYPE, 'it_IT.utf8');
15  #echo setlocale(LC_ALL, 0);
16  #date_default_timezone_set("GMT");
17  date_default_timezone_set("Europe/Rome");
18
19  $data = new stdClass();
20
21  foreach($files as $f) {
22
23    $fd = fopen($f, "r");
24
25    // kind text, device_sn text, device_name text, port_number integer, sensor_sn text, sensor_name text,
26    #$device = new stdClass();
27    $sensor = new stdClass();
```

... lines 27 to 103

```
103   array_push($data->$device_name, $el);
104
105   fclose($fd);
106 }
107
108 #$pagination = new stdClass();
109 #$pagination->per_page = 2000;
110 #$pagination->page_num = 1;
111 #$pagination->next_url = "";
112 #$pagination->max_mrid = 51345;
113 #$pagination->page_num_readings = 1;
114 #$pagination->page_num_outputs = 25;
115 #$pagination->page_start_date = "2022-10-03 15:00:00+02:00";
116 #$pagination->page_end_date = "2022-10-03 15:00:00+02:00";
117 #$pagination->page_start_mrid = 51252;
118 #$pagination->page_end_mrid = 51252;
119
120 $f = [];
121 #$f['pagination'] = $pagination;
122 $f['data'] = $data;
123 //$j = json_encode($f, JSON_PRETTY_PRINT);
124 $j = json_encode($f);
125 print($j . PHP_EOL);
126
127 ?>
```

Fig. 11 – The (part of) convert_scada.php code.

2.2.3 Borehole sensors

The DIVER sensors by Eiikelkam were established by PP1 in the 10-m deep boreholes drilled in the Venice site. The DIVERs send daily an email (Fig. 12) with the data recorded during the previous 24 hours. The convert-diver.php software (Fig. 13) was develop to convert the records in the .json format, after which the import.php (Fig. 7) and insert_data.php (Fig. 8) codes are use as in the previous case.

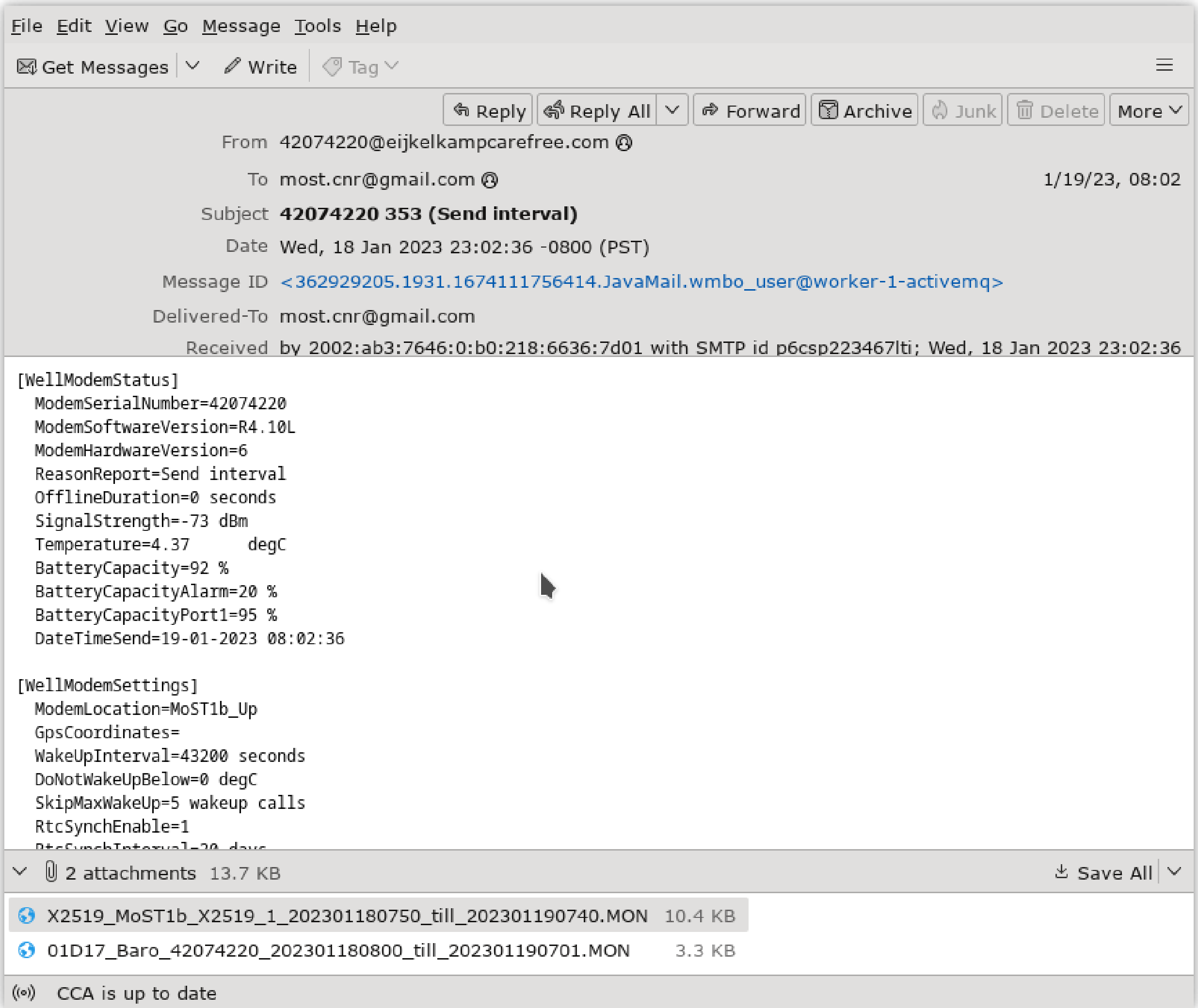

Fig. 12 – The email sent by the DIVER modem daily with the recorded data.

```php
1   <?php
2   #require_once "insert_data.php";
3
4   $output_db = "test.db";
5   $debug = 0;
6
7   $files = [ 'data/X2519_MoST1b_X2519_1_202301180750_till_202301190740.MON'];
8
9   if ($argc > 1) {
10    $files = $argv;
11    array_shift($files);
12  }
13
14  setlocale(LC_CTYPE, 'it_IT.utf8');
15  #echo setlocale(LC_ALL, 0);
16  #date_default_timezone_set("GMT");
17  #date_default_timezone_set("Europe/Rome");
18
19
20  function find_data($fd, $string) {
21    $row = false;
22    while (true) {
23      $row = fgets($fd);
24      if ($row === false) break;
25      $ret = strstr($row, $string);
26      if ($ret != false) {
27        break;
28      }
29    }
```

... lines 29 to 198

```php
199     $r = [];
200     #$r['timestamp_utc'] = $ts;
201     #$r['datetime'] = date("Y-m-d H:i:s", $ts);
202     #$r['tz_offset'] = 0;
203     $r['timestamp_utc'] = $dateTime->getTimestamp();
204     $r['datetime'] = $dateTime->format('Y-m-d H:i:sP');
205     $r['tz_offset'] = $dateTime->getOffset();
206
207     $value = str_replace(",", ".", $row[1]);
208     $value = trim($value);
209     $r['value'] = $value;
210     $r['precision'] = 2;
211     $r['mrid'] = 0;
212     array_push( $el['readings'], $r);
213     $counter++;
214   }
215
216   array_push($data->$device_name, $el);
217
218   fclose($fd);
219 }
220
221 $f = [];
222 #$f['pagination'] = $pagination;
223 $f['data'] = $data;
224 //$j = json_encode($f, JSON_PRETTY_PRINT);
225 $j = json_encode($f);
226 print($j . PHP_EOL);
227
228 ?>
```

Fig. 13 – The (part of) convert_diver.php code.

3. The MoST/SeCure – Croatian site

The MoST/SeCure smartphone App covering for Neretva study area monitoring system and obervations can be reached from the website https://secure.waveform.hr/dashboard https://most.dice.unipd.it/.

A few print-screens of the main App features are provided in Fig. 14 to Fig. 21.

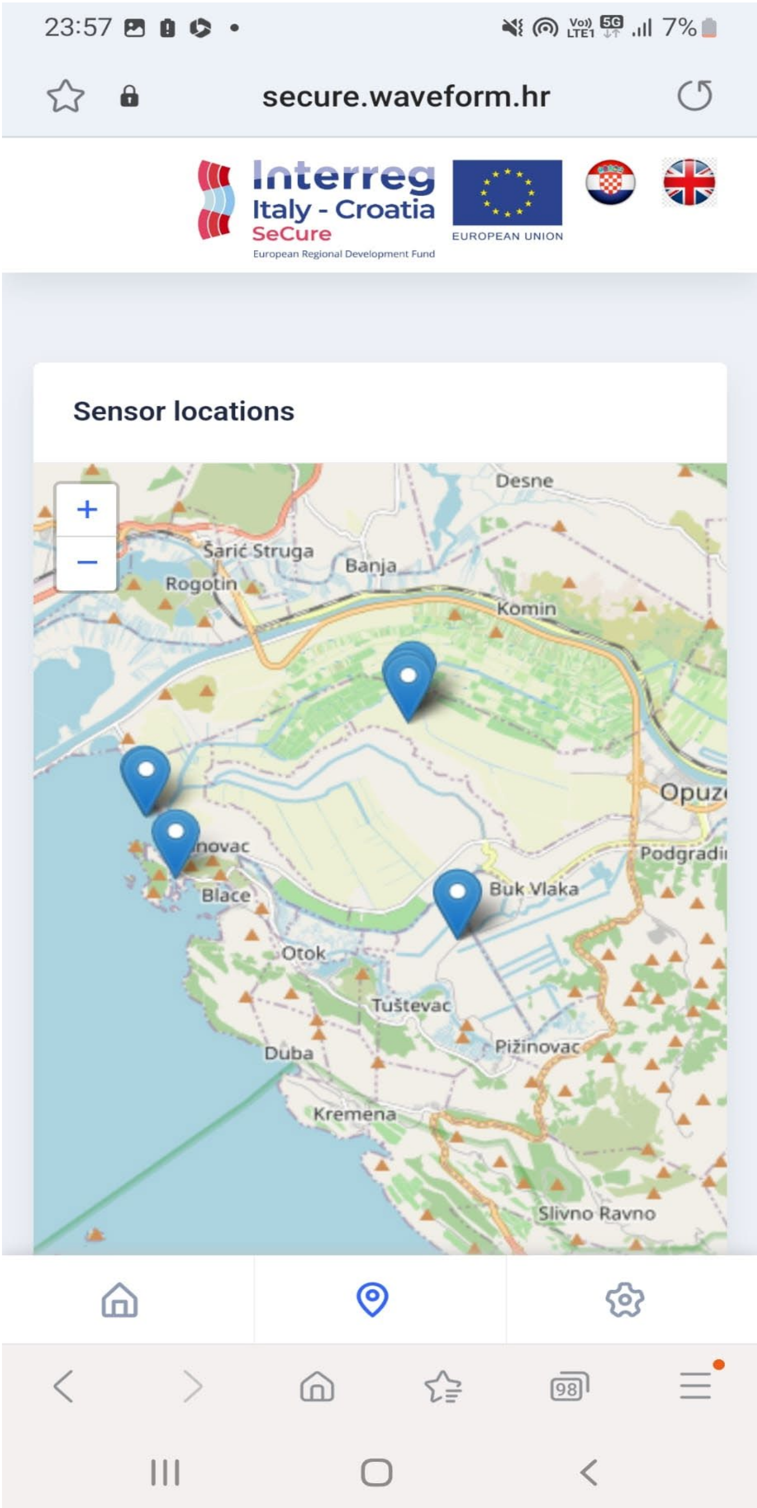

Fig. 14 – Main SeCure App map with sensor locations.

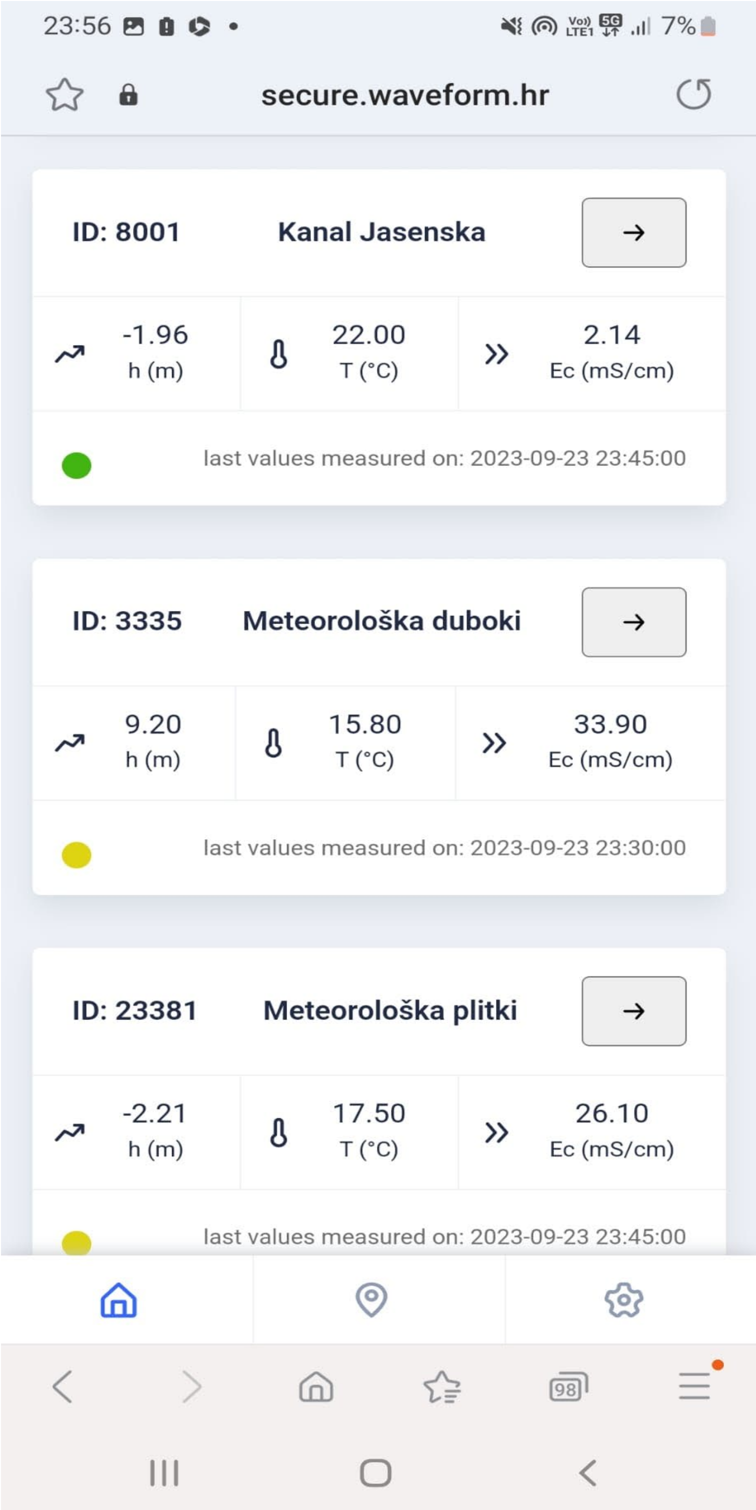

Fig. 15 –SeCure App map with available sensor list.

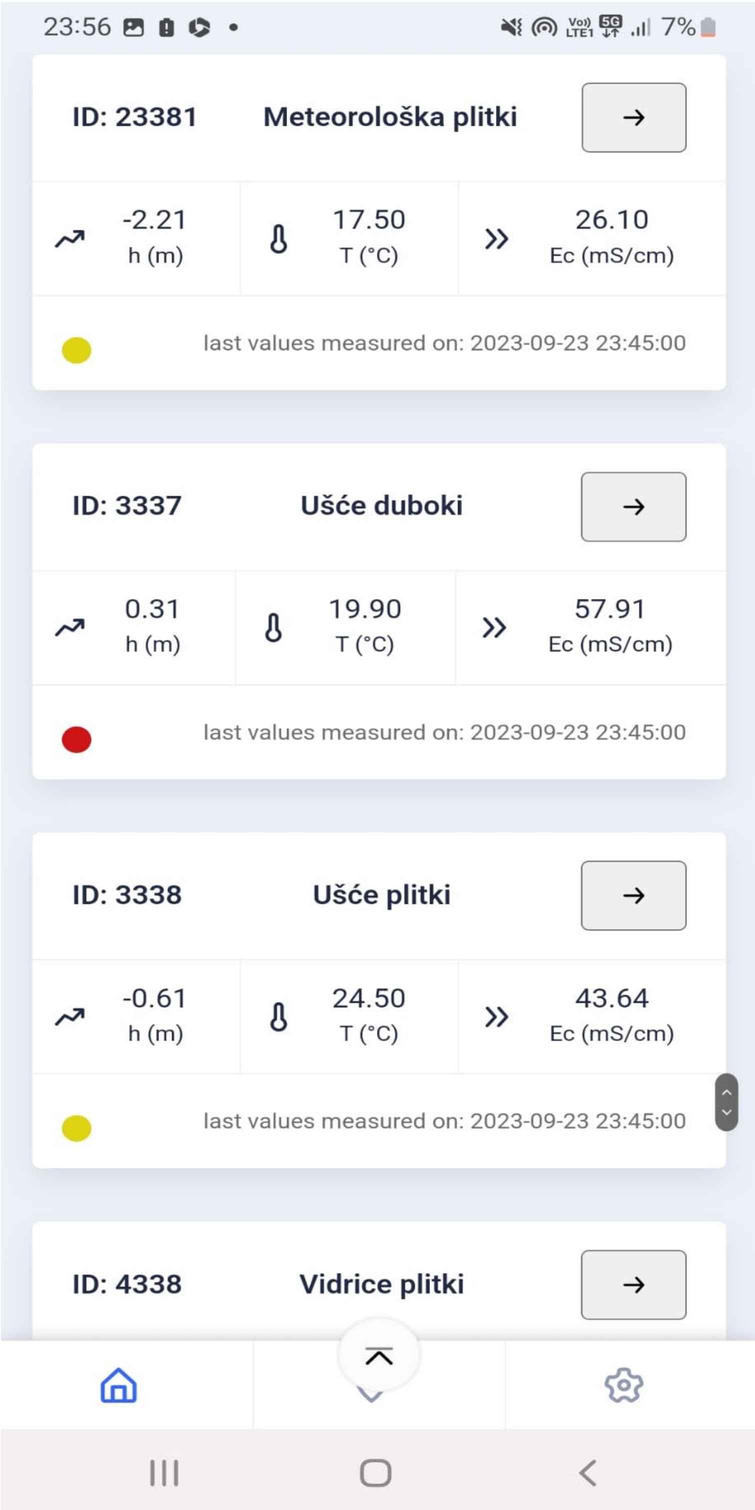

Fig. 16 –SeCure App map with available sensor list.

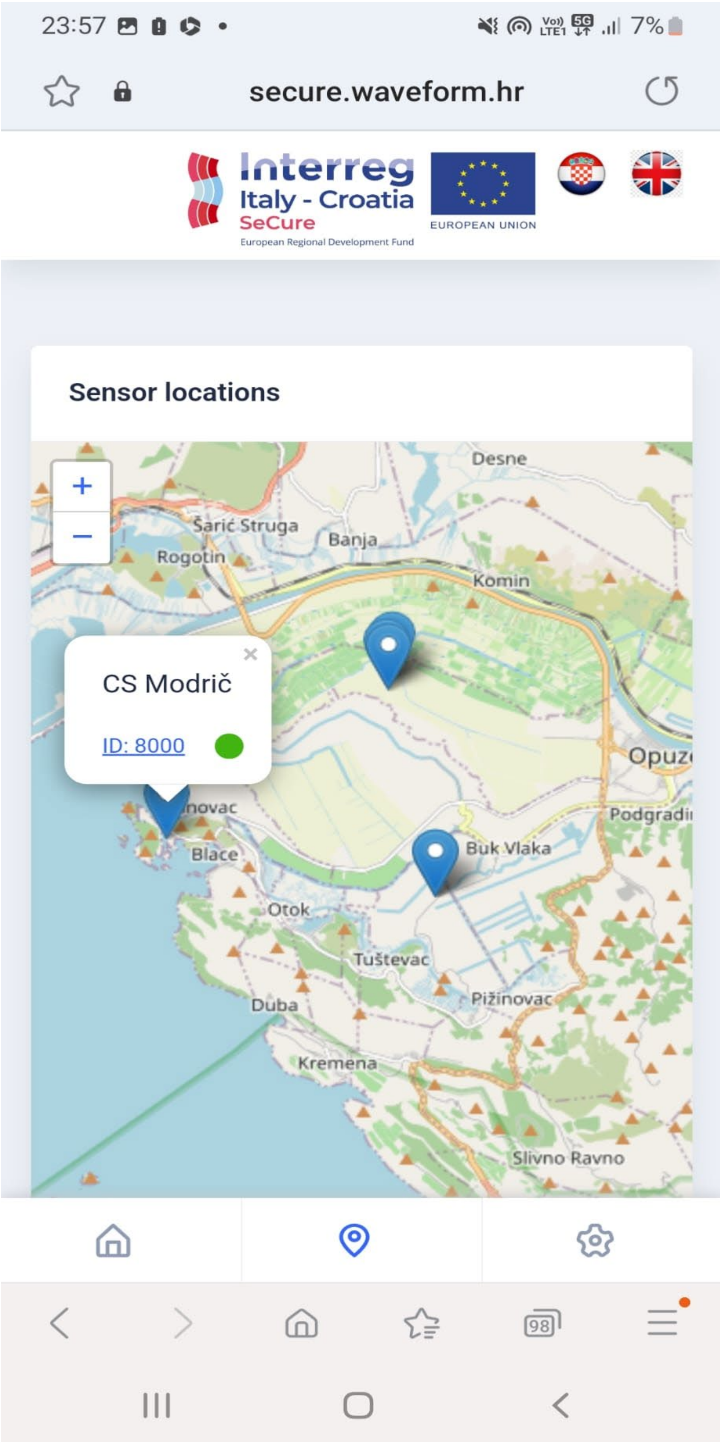

Fig. 17 – Main SeCure App map with sensor location selection option

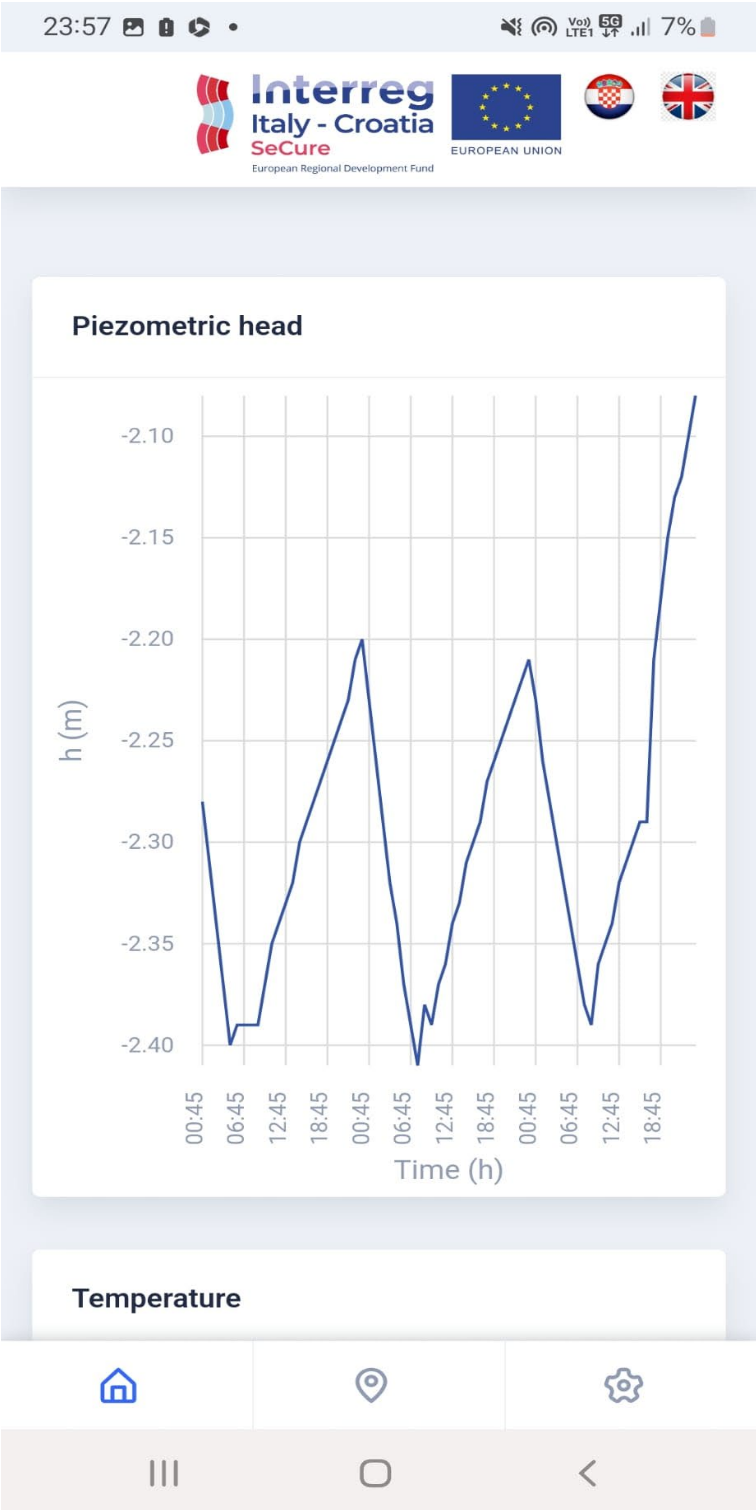

Fig. 18 – SeCure App with the insight to observed piezometric head

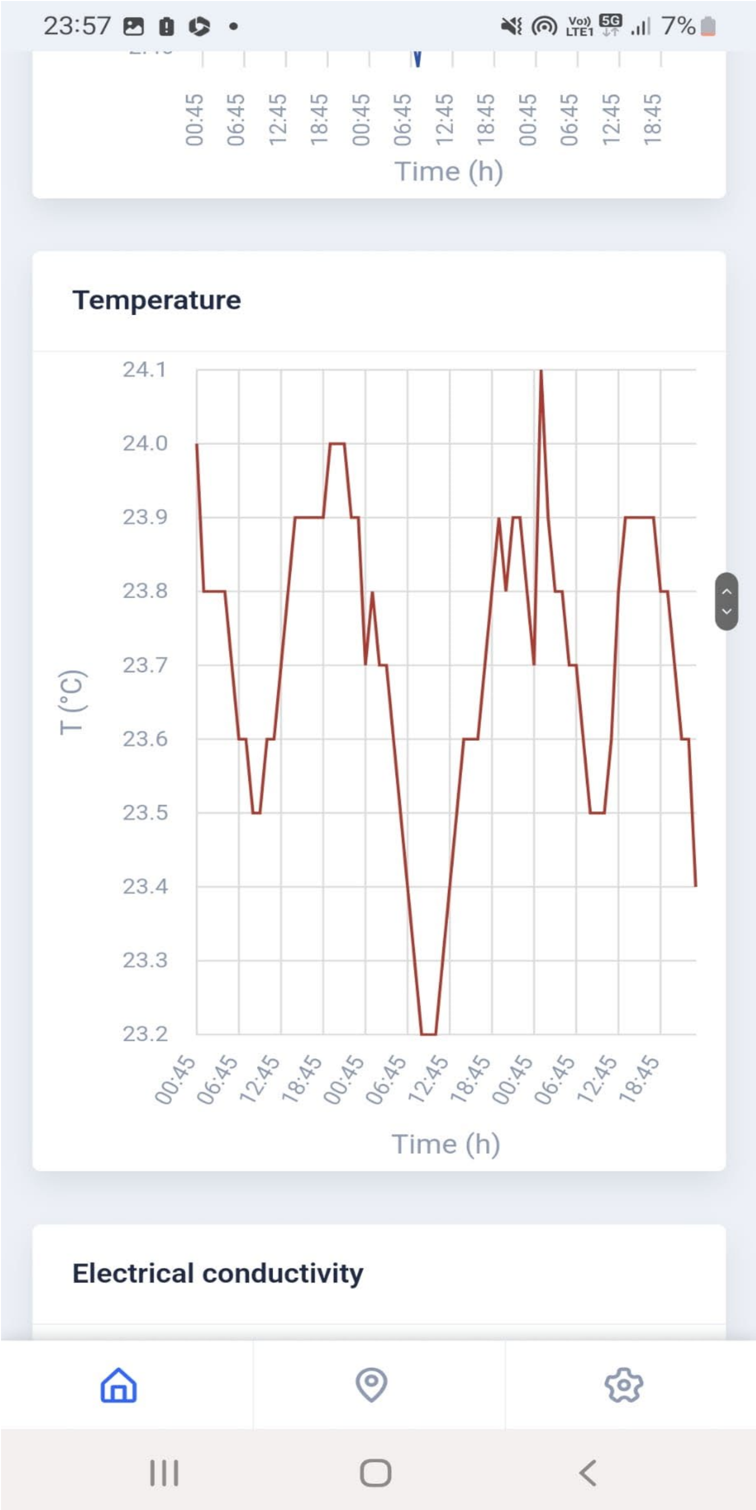

Fig. 19 – SeCure App with the insight to observed temperature

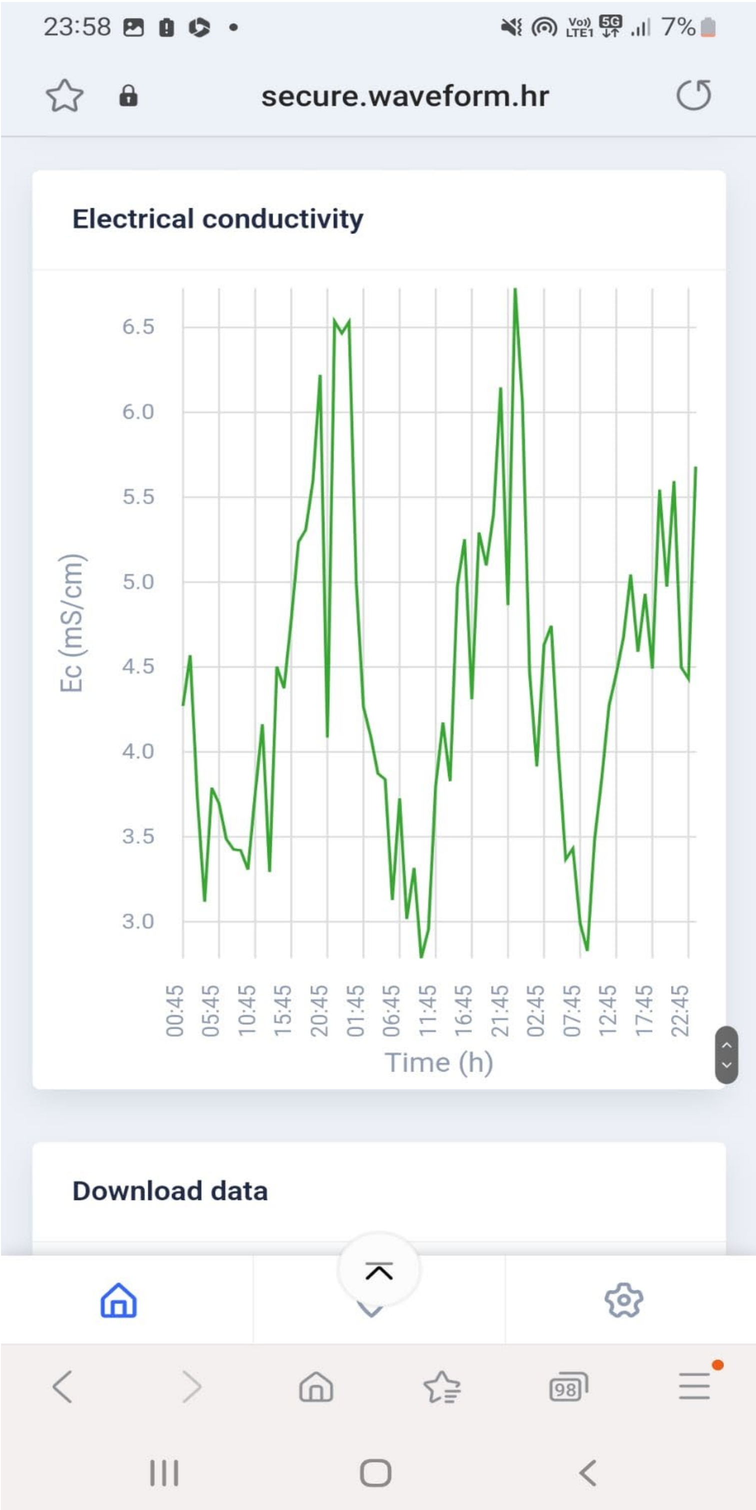

Fig. 20 – SeCure App with the insight to observed EC

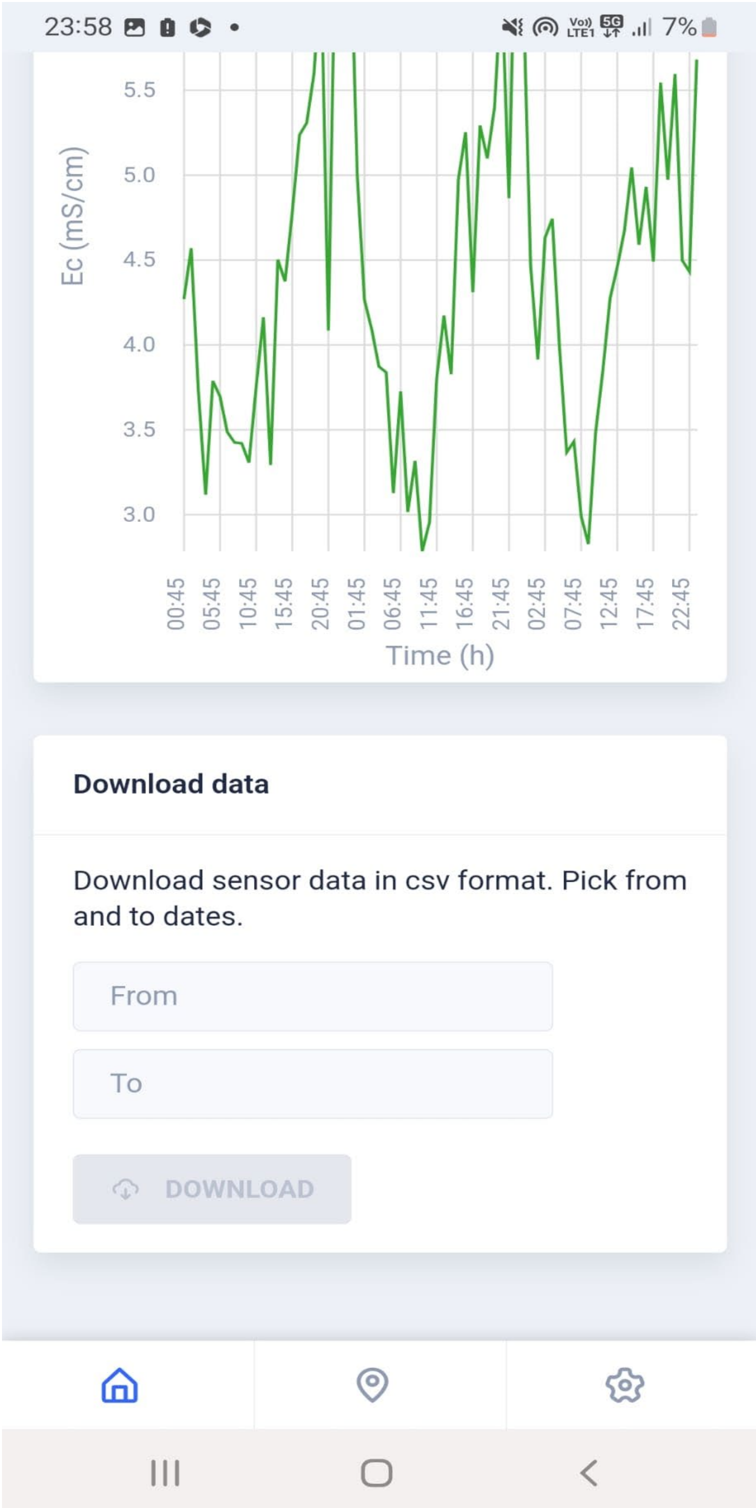

Fig. 21 – SeCure App with observed data download option